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## ⑯ 特許請求の範囲

1 供給側および出口側に各々ガイドロールを有し、該ガイドロールの間に互に平行な複数の拡幅ロールを備えた装置であつて、該拡幅ロールへの複数本の互に平行に並べた繊維束の入出角が30~90°に各拡幅ロールが配置されてなる繊維束拡幅装置。

2 梨地表面を有する拡幅ロールを用いることを特徴とする特許請求の範囲第1項記載の繊維束拡幅装置。

## 発明の詳細な説明

本発明は、繊維束の拡幅又は開織に係わり、一方向引き揃え繊維束のシート状テープを均一にかつ毛羽等の発生を少なく連続的に製造する装置に係わる。

現在、炭素繊維、ガラス繊維、全芳香族ポリアミド繊維等の補強用繊維束テープにエポキシ樹脂、不飽和ポリエステル樹脂等を繊維束テープにエポキシ樹脂、不飽和ポリエステル樹脂等を始めとする熱硬化性樹脂を含浸せしめたプリプレグは板バネやハニカム構造材等の工業材料、あるいは

釣竿、ゴルフシャフト、バトミントンシャフト等のスポーツ、レジャー用機材として広く利用されている。さらに近年においては航空機材料、自動車用素材、医療用素材において上述したプリプレグを用いた成形材料を利用する検討が多く行われ一部で実用化されるに至っている。

このようなプリプレグの使用、用途の多様化に伴い、均一で薄いプリプレグの必要性も増す傾向にある。均一で薄いプリプレグは薄肉成形体を得るためだけでなく、一方向引揃え補強繊維強化樹脂の異方性の特徴を生かした多彩な設計を可能ならしめ、複合材料の使用用途をさらに拡大するものと考えられる。

均一でしかも薄いプリプレグを作るためには通常、細い繊維束あるいはフライメント数の少ない繊維束を一方向に引揃えて薄い繊維束シートを作るか、比較的太い繊維束、あるいはフライメント数の多い繊維束を何んらかの手段によつて拡幅し一方向に引揃えて薄い繊維束シートを作るかのいずれかの方法が採られる。

一般に細い繊維束あるいはフライメント数の少

ない繊維束は高価であるため、出来る限り太い繊維束、フィラメント数の多い繊維束を拡幅し薄い繊維束シートを作りプリプレグ化する方が有利と考えられる。

本発明者らは、薄いプリプレグシートの製造方法につき種々検討の結果本発明に到達したものである。即ち本発明の要旨とするところは、供給側および出口側に各々ガイドロールを有し該ガイドロール間に互に平行な複数の拡幅ロールを備えた装置であつて該拡幅ロールへの複数本の互に平行に並べた繊維束の入出角が30~90°に各拡幅ロールが配置されてた繊維束拡幅装置にある。

本発明による装置によれば引揃え繊維束を連続的に効率良く拡幅できるためプリプレグ製造装置の一部として使用すれば高品質の薄いプリプレグを得ることができる。

図1に本発明による装置の原理を説明するための模式図を示す。

図1Aに半径Rなるロールの表面を張力Tのもとに走行する厚み△Rの繊維束を示す。又a及びbの部分の繊維束断面の模式図を同図Bに示す。

図1Aにおいて繊維束を構成する各単繊維の走行方向への互いのすべりが無ければ、一番外を走

行する単繊維は  $\frac{\Delta R}{R}$  なる歪みを受け  $\Delta T = E$

$\frac{\Delta R}{R}$  の過剰な張力が加わり、それに伴ない  $\Delta P$  なるで内側へ押し付けられる。

このような原理により繊維束内の外側を走行する繊維は内側へ内側へと押し付けられる。この時に各単繊維間で走行方向と直角の方向にすべりが生じると各単繊維が内側へ内側へと沈み込み結果としてP'なる力で横方向へ押し拡げられる。この時ロールが固定されている場合には、ロールと接する単繊維の横方向の重さが増すため、さらに効果がある。これはロールがつれ回わりで回転する場合では静止マサツ状態となるが固定されている場合には動マサツ状態となつて横方向の繊維すべりがよくなるためであると考えられる。

上述の原理にもとづき繊維束の拡幅装置を種々検討した結果本発明の装置を開発するに至つた。

図2A, Bに本発明による装置の概略図を示し

た。

図2AにおいてロールA及びEはガイドロールをB, C, Dは拡幅用ロールを示す。図2Bに炭素繊維束を通した時の例を示す。拡幅ロール径5は、拡幅効果、繊維束の損傷、ロール強度等を考慮すれば6~60mm、望ましくは10~30mmが適當である。

又、図2Aの繊維束の拡幅用ロールへの入出角、 $\alpha$ °,  $\beta$ °,  $\gamma$ °は30~90°が適當である。

10 30°以下では張力によるロールへの負荷が大となりロールの曲がりの原因となる他、繊維束の損傷による毛羽の発生が多く実用とはならなかつた。又、90°を越すと繊維束の拡幅効果が少なく、目的の薄いプリプレグを製造するには不適當である。15 拡幅用ロールは回転及び固定が可能で目的に応じて選択できるようになつてゐる。又、ロール材質としてはSK材又はステンレス材が適當であるが、表面はスベリを良くし繊維束の拡幅を促進するためと、毛羽の発生を抑えるために、梨地20 表面とするのが良い。さらに摩耗を防ぎ長期使用に耐え得るものとしてはロールの表面にクロムメッキを施した後、梨地加工を行なつたものが最適である。

25 拡幅用ロールの本数3本以上が適當であるが、図2A, A及びEのガイドロールを梨地表面の固定ロールとすれば、わずかではあるが、拡幅効果を持つので、図3の如き3本ロールの装置でもある程度の拡幅は可能である。しかしながら充分な効果を得るためにには図2Bに示すように複数の拡30 幅ロールを設けることが必要である。

以下に本発明による実施例を示す。

#### 実施例 1

図2Aの如き装置であつて、 $\alpha$ °,  $\beta$ °,  $\gamma$ °がいずれも45°、ガイドロールを含む5本のロールがすべて回転固定が可能な拡幅装置をプリプレグ製造装置に組み込み、糊剤付着量0.3wt%の炭素繊維(3000fl)で製造した時のプリプレグの外観及び繊維束一本当りの拡がり幅及び1プライ当りの理論成形厚み( $V=60\%$ )を表1に示した。表中40 a, b, c, dは、ロールの表面加工、ロールの固定、回転等の条件の違いを示す。なお繊維束に加わる張力は1本当り約1.5kgであつた。

## 表 1

	ロール表面	ロールの固定、回転条件	プリプレグ外観	繊維束1本当たりの幅(mm)	1プライ当たりの理論成形厚み(mm)
a	クロムメッキ、梨地加工	全ロール固定	毛羽少し有り	4.4~4.5	0.0428
b	"	ガイドロールのみ回転	毛羽ほとんど無し	4.3~4.4	0.0439
c	"	全ロール回転	毛羽無し、目閉き少し有	3.3~3.9	0.0552
d	クロムメッキ鏡面仕上	ガイドロールのみ回転	毛羽多数、目閉き少し有	4.0~4.3	0.0455

## 比較例 1

\* $\alpha^\circ$ ,  $\beta^\circ$ ,  $\gamma^\circ$ の角度を変更して実験したところ、次  
実施例1と同様にして、但し拡幅用ロールの\* のような結果が得られた。

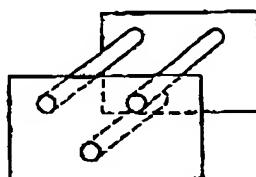
## 表 2

	$\alpha^\circ$	$\beta^\circ$	$\gamma^\circ$	ロール表面	ロールの固定、回転条件	プリプレグ外観	繊維束1本当たりの幅(mm)
イ	100	100	100	クロムメッキ梨地加工	全ロール固定	毛羽少し有り 目閉き少し有り	3.0~3.5
ロ	120	120	120	"	"	毛羽無し 目閉き多数	2.5~3.2
ハ	100	100	100	クロムメッキ鏡面	"	毛羽多数	4.3~4.5
ニ	25	25	25	クロムメッキ梨地加工	ガイドロールのみ回転	"	4.5~4.7
ホ	25	25	25	"	全ロール回転	毛羽無し 目閉き少し	3.5~4.0
ヘ	25	25	25	"	全ロール固定	毛羽非常に多し	4.7~5.0

## 図面の簡単な説明

図1は本発明の装置の原理を示す模式図、図2 30 及び3は本発明の装置の概略図を示すものである。

## ＊ 3 図



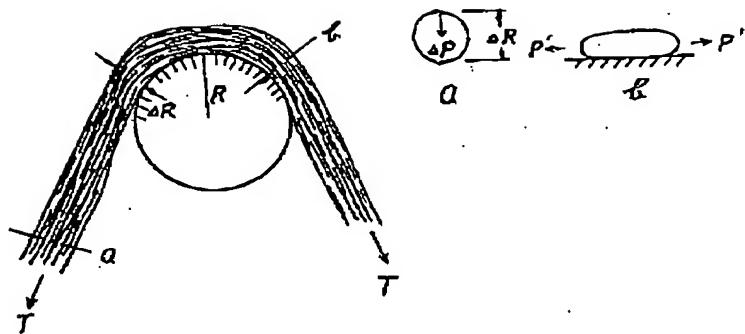
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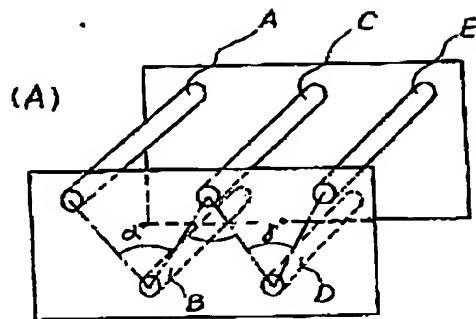
第 1 図

(A)

(B)

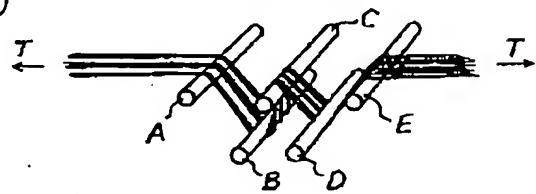


第 2 図



(B)

走行方向



(English Translation of Japanese Patent Application  
After-Grant Laid-open No.3-31823)

Apparatus for widely spreading a fibers bundle

WHAT IS CLAIMED IS:

1. Apparatus for widely spreading a fibers bundle comprising a guide roller provided on an entrance side and an exit side respectively of said apparatus and a plurality of spreading rollers disposed in parallel with each other wherein said respective rollers are disposed such that a plurality of fibers bundles aligned in parallel roll over said respective rollers with an angle ranging from 30 degrees to 90 degrees.
2. Apparatus for widely spreading a fibers bundle according to claim 1 wherein said respective rollers are satin finished on the surface.

DETAILED DESCRIPTION OF THE INVENTION

The invention relates to an apparatus for widely spreading a fibers bundle, more specifically, pertaining to an apparatus for continuously producing a spread fibers bundle sheet or tape whose filaments are uni-directionally aligned side by side with a uniform thickness and with the restraint of causing fluffs on the fibrous surface.

Currently, a pre-impregnation sheet in which such a reinforced fibers bundle tape as being made from carbon fibers, glass fibers, aromatic polyamide fibers is impregnated with such thermoset resin as epoxy resin and non-saturated polyester resin is widely adopted for such industrial material as a plate spring and a honeycomb-built structure and for such sports items and leisure goods as a fishing rod, a golf shaft and a badminton shaft. Further, in recent years, such materials as molded from the above-mentioned pre-impregnation sheet are on review to be used for the assembly parts of airplanes, automobiles and medical instruments and some of them are put into practice.

In accordance with the diversified use of such pre-impregnation sheet, such pre-impregnation sheet as being uniform and smaller in thickness is in acute demand. Such uniformly and thinly prepared pre-impregnation sheet enables

not only a thinly molded product to be produced, but also such products as making most of the anisotropic behavior of fiber reinforced complex material to be designed in variety, which further expands the use of such complex material.

In order to form a uniformly and thinly prepared pre-impregnation sheet, normally, either fibers bundles smaller in diameter or fibers bundles respectively comprising a small number of filaments are uni-directionally aligned side by side so as to be formed into a spread fibers bundles sheet smaller in thickness or fibers bundles larger in diameter or fibers bundles respectively comprising a large number of filaments are widely spread so as to be formed into a spread fibers bundles sheet smaller in thickness.

In general, a fibers bundle smaller in diameter or comprising a small number of filaments is expensive, so that it is advantageous to widely spread a fibers bundle larger in diameter or comprising a large number of filaments so as to form a spread fibers bundle sheet smaller in thickness for preparing a pre-impregnation sheet.

The present inventors have tired and erred on the production method of a pre-impregnation sheet smaller in thickness and reached the inventive step of the invention as disclosed herein. That is to say, the gist of the invention is to provide an apparatus for widely spreading a fibers bundle comprising a guide roller provided on an entrance side and an exit side of the apparatus and a plurality of spreading rollers aligned in parallel with each other and disposed between the guide rollers wherein a plurality of fibers bundles aligned in parallel roll over the respective rollers with an angle ranging from 30 degrees to 90 degrees.

The apparatus according to the invention allows a fibers bundle to be widely spread in a continuous manner and with efficiency so that a high-quality pre-impregnation sheet smaller in thickness is prepared with the apparatus hereof incorporated into a pre-impregnation sheet production apparatus.

Figure 1 is an explanatory view to illustrate the principle of the apparatus according to the invention.

Figure 1 A shows a fibers bundle with a thickness of  $\Delta R$  running on the surface of the roller having radius R under a tension T. Figure 1 B shows a sectional view of the bundle taken along a and b of Figure 1A.

In Figure 1A, without the mutual slippage of the respective monofilaments towards the moving course of the fibers bundle, the monofilaments disposed in the outermost positions thereof

are subjected to the strain expressed with  $\frac{\Delta R}{R}$  so as to be applied an excessive tension expressed with  $\Delta T = E t \frac{\Delta R}{R}$  to such monofilaments, in accordance with which such monofilaments are pushed inwards with the force expressed with  $\Delta P$ .

On such principle as explained above, the monofilaments disposed in the outermost position of the bundle are further and further pushed inwards, upon which slippage occurring crosswise with regard to the moving course of the bundle among the respective monofilaments resulting in further sinking them within the bundle so that they are spread widthwise with the force of  $P'$ . In case where the respective rollers are axially fixed without rotation, the weight of the respective monofilaments in contact with the respective rollers is carried widthwise with regard to the respective rollers so that spreading effect is enhanced. This is because the respective monofilaments are in static friction with the respective rollers where the rollers rotate together with the bundle while they are in kinetic friction with the latter where they are axially fixed so that the slippage of the respective monofilaments widthwise with regard to the moving course of the bundle is enhanced.

As a result that the variety of apparatuses for spreading a fibers bundle has been tried on the basis of the principle as mentioned above, we have invented an apparatus as disclosed herein.

Figure 2A and 2B schematically show an apparatus according to the invention.

In Figure 2A, reference letters A and E indicate guide rollers while B, C and D indicate spreading rollers. Figure 2B shows one example in which the respective carbon fibers bundles are rolled over the respective rollers. The diameter of the respective spreading rollers ranges from 6 mm to 60 mm, more preferably ranging from 10 to 30 mm in order to enhance spreading effect and to prevent the respective bundles from being damaged and secure the durability of a roller.

The angle  $\alpha^\circ$ ,  $\beta^\circ$ , and  $\gamma^\circ$  by which the respective bundles roll over the respective spreading rollers as shown in Figure 2A, preferably, range from  $30^\circ$  to  $90^\circ$ .

If such angle is less than  $30^\circ$ , practically speaking, it causes the tensile force applied to the respective bundles to tend to the respective rollers so as to bend the latter. Besides, a lot of fluffs occur on the surface of the respective bundles. In turn, if such angle is more than  $90^\circ$ , there is no spreading effect on the respective bundles so that it is impractical to produce a pre-impregnation sheet smaller in thickness. The respective spreading rollers may be axially fixed or rotate, which is selectable on a case-by-case basis. The respective spreading rollers are preferably made from an SK material or stainless steels, the surface of which roller is satin finished for the purpose of facilitating the slippage of the respective bundles thereon and restraining fluffs from occurring on the surface of the respective bundles. The optimum spreading roller that is abrasion-proof and durable for a long period of time is such that its surface is chromium plated and then satin finished.

More than three spreading rollers are appropriate for carrying out the invention, but provided that the guide rollers referred to as A and E in Figure 2A are satin finished and axially fixed, the apparatus as shown in Figure 3 comprising three rollers may perform spreading operation to some extent. However, for the purpose of enhancing spreading effect, a plurality of

The preferred embodiment of the invention is described below.

### Example 1

An apparatus as shown in Figure 2A whose five rollers including guide rollers may be axially fixed or rotate, over which spreading rollers the respective bundles roll by the angle of 45°, is incorporated into a pre-impregnation sheet production apparatus. The appearance of the sheet made from the respective carbon fibers bundles respectively comprising 3000 monofilaments containing 0.3 weight percent of a sizing agent and the spread width per bundle as well as the theoretical thickness per spread sheet under the condition that the ratio by which the filaments are contained in the sheet amounts to 60 % are shown in Table 1, which table is divided into sections a, b, c and d according to such conditions as roller surface finish, fixing or rotating roller and so forth. To note, the tension applied to the respective bundles is about 1.5 Kg.

TABLE 1

Surface Finish		Fix or rotate Rollers	Appear- ance	Width (mm)	Thickness (mm)
a	Chromium plated, satin finished	Fix all	A few Fluffs	4.4 to 4.5	0.0428
b	-ditto-	Rotate guide rollers only	Scarce Fluffs	4.3 to 4.4	0.0439
c	-ditto-	Rotate all	No fluff, A few gaps	3.3 to 3.9	0.0552
d	Chromium plated, Mirror surface finished	Rotate guide Rollers only	A lot of Fluffs, A few Gaps	4.0 to 4.3	0.0455

### Comparison 1

In the same way as the above example 1, but with the angle by which the respective bundles roll over the respective guide rollers modified, the following result is obtained.

Table 2

$\alpha^\circ$ $\beta^\circ$ $\gamma^\circ$			Roller Surface	Fix or rotate Rollers	Appearance	Width (mm)	
a	100	100	100	Chromium plated, satin finished	Fix all	A few Fluffs and gaps	3.0 to 3.5
b	120	120	120	-ditto-	-ditto-	No fluff, But with A lot of Gaps	1.5 to 3.2
c	100	100	100	Chromium plated, mirror surface finished	-ditto-	A lot of Fluffs	4.3 to 4.5
d	25	25	25	Chromium plated, satin finished	Rotate guide rollers only	A lot of Fluffs	4.5 to 4.7
e	-ditto-	-ditto-	-ditto-	Rotate all	No fluff, a few gaps	3.5 to 4.0	
f	-ditto-	-ditto-	-ditto-	Fix all	A very lot of fluffs	4.7 to 5.0	

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an explanatory view to show the principle of the apparatus according to the invention and Figures 2 and 3 schematically show the arrangement of the apparatus according to the invention.

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